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**Report No.** 10838

PROJECT COMPLETION REPORT

KOREA

ELECTRONICS TECHNOLOGY PROJECT
(LOAN 1676-KO)

JUNE 30, 1992

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Industry and Energy Operations Division
Country Department II
Asia Region

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## CURRENCY EQUIVALENTS

Korean Won

| Year | (Won per US$) |
|---|---|
| 1979 | 484 |
| 1980 | 607 |
| 1981 | 681 |
| 1982 | 731 |
| 1983 | 776 |
| 1984 | 806 |
| 1985 | 870 |
| 1986 | 881 |
| 1987 | 823 |

## WEIGHTS AND MEASURES

All weights and measures in metric units.
1 square meter ($m^2$) = 10.76 square feet ($ft^2$)
1 kilometer (km) = 0.62 mile

## ABBREVIATIONS AND ACRONYMS

| | | |
|---|---|---|
| AIT | - | American Information Technology Co. Ltd. (USA) |
| EPB | - | Economic Planning Board |
| ETRI | - | Electronics and Telecommunications Research Institute |
| JFIC | - | Fine Instruments Center |
| IC | - | Integrated Circuit |
| ICE | - | Integrated Circuit Engineering Corporation |
| KAIS | - | Korea Advanced Institute of Science |
| KIET | - | Korea Institute of Electronics Technology |
| KIST | - | Korea Institute of Science Technology |
| MCI | - | Ministry of Commerce and Industry |
| MOC | - | Ministry of Communication |
| MOST | - | Ministry of Science and Technology |
| PCB | - | Printed Circuit Board |
| PCR | - | Project Completion Report |
| R&D | - | Research and Development |
| RD&E | - | Research, Development and Engineering |
| ROM | - | Read-only memory |
| UNDP | - | United Nations Development Programme |
| VLSI | - | Very-large-scale integration |
| VTI | - | VSLI Technology, Inc. (USA) |
| VTR | - | Video Tape Recorder |

## FISCAL YEAR

January 1 to December 31

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THE WORLD BANK
Washington, D.C. 20433
U.S.A.

Office of Director-General
Operations Evaluation

June 30, 1992

MEMORANDUM TO THE EXECUTIVE DIRECTORS AND THE PRESIDENT

SUBJECT: Project Completion Report on Korea
Electronics Technology Project (Loan 1676-KO)

Attached, for information, is a copy of a report entitled "Project Completion Report on Korea - Electronics Technology Project (Loan 1676-KO)" prepared by the Electronics and Telecommunications Research Institute with the Overview, Basic Data Sheet and Highlights prepared by the Industry and Energy Operations Division, Country Department II, Asia Region.

Yves Rovani

by H. Eberhard Köpp

Attachment

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# PROJECT COMPLETION REPORT

## KOREA

## ELECTRONICS TECHNOLOGY PROJECT
(Loan 1676--KO)

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## KOREA

## ELECTRONICS TECHNOLOGY PROJECT
(Loan 1676-KO)

## PREFACE

This report covers the Electronics Technology Project in Korea supported by Loan 1676-KO. The loan of US$29.0 million was made to the Republic of Korea for a project carried out by the Korea Institute of Electronics Technology (KIET), which later merged into another institute called Electronics and Telecommunications Research Institute (ETRI), was approved on March 22, 1979. The loan became effective on June 28, 1979, and was closed on June 30, 1986, four years after the original plan.

The Project Completion Report (PCR) was prepared by the Electronics and Telecommunications Research Institute (ETRI), the implementing agency of the Government of Korea. The PCR Overview, Basic Data Sheet and Highlights were prepared by AS2IE.

# PROJECT COMPLETION REPORT

## KOREA

## ELECTRONICS TECHNOLOGY PROJECT
(Loan 1676-KO)

## BASIC DATA SHEET

### KEY PROJECT DATA

| Item | Appraisal Expectation | Actual |
|---|---|---|
| Total Project Costs (US$ million) | 56.0 | 33.0 |
| Loan Amount (US$ million) | 29.0 | 29.0 |
| Disbursed | 29.0 | 23.9 |
| Cancelled | - | - |
| Project Completion Date | December 1982 | June 1986 |
| Proportion of Expense Spent by Appraisal Target Date | 100% | 59% |
| Financial Performance | | Fair |
| Institutional Performance | | Fair |

### CUMULATIVE ESTIMATED AND ACTURAL DISBURSEMENTS

| | FY79 | FY80 | FY81 | FY82 | FY83 | FY84 | FY85 | FY86 | FY87 |
|---|---|---|---|---|---|---|---|---|---|
| Appraisal Estimate (US$ million) | 13.30 | 21.90 | 27.00 | 29.00 | - | - | - | - | |
| Actual (US$ million) | 0.04 | 7.95 | 14.71 | 17.12 | 20.40 | 20.59 | 20.68 | 22.64 | 23.94 |
| Actual as % of Appraisal | - | 36 | 54 | 59 | 70 | 71 | 71 | 78 | 83 |

Date of Final Disbursement: January 30, 1987

### STAFF INPUTS
(staff weeks)

| Fiscal Year | Preappraisal | Appraisal | Negotiation | Supervision | Other | Total |
|---|---|---|---|---|---|---|
| 1977 | 2.5 | - | - | - | - | 2.5 |
| 1978 | 48.5 | - | - | - | 1.5 | 50.0 |
| 1979 | 28.4 | 33.2 | 5.5 | 3.5 | 11.6 | 82.2 |
| 1980 | - | - | - | 13.9 | - | 13.9 |
| 1981 | - | - | - | 24.6 | - | 24.6 |
| 1982 | - | - | - | 32.2 | - | 32.2 |
| 1983 | - | - | - | 13.6 | - | 13.6 |
| 1984 | .3 | - | - | 22.7 | - | 23.0 |
| 1985 | - | - | - | 10.5 | - | 10.5 |
| 1986 | - | - | - | 9.9 | .2 | 10.1 |
| 1987 | - | - | - | .4 | - | .4 |
| 1988 | - | - | - | 5.7 | - | 5.7 |
| 1989 | | | | 2.3 | | 2.3 |
| Total | 79.7 | 33.2 | 5.5 | 139.3 | 13.3 | 271.0 |

## MISSION DATA

| Item | Date | Duration (days) | Number of persons | Staff-weeks /a | Date of Report |
|---|---|---|---|---|---|
| Identification | 11/75 | 7 | 1 | 1.0 | 12/03/75 |
| Preparation | 7/77 | 20 | 2 | 5.7 | 8/18/77 |
| Appraisal | 5/78 | 16 | 4 | 9.1 | 11/22/78 |
| Total | - | - | | 15.8 | - |
| Supervision I | 8/79 /b | 5 | 1 | 0.4 | 10/15/79 |
| Supervision II | 3/80 /c | 5 | 2 | 0.5 | 4/30/80 |
| Supervision III | 5/80 | 5 | 2 | 1.4 | 5/28/80 |
| Supervision IV | 11/80 | 5 | 3 | 2.1 | 12/15/80 |
| Supervision V | 7/81 /d | 8 | 3 | 1.1 | 8/28/81 |
| Supervision VI | 6/82 /e | 9 | 3 | 2.0 | 8/19/82 |
| Supervision VII | 12/82 /e | 8 | 2 | 1.1 | 1/21/83 |
| Supervision VIII | 11/83 /e /f | 12 | 3 | 1.3 | 1/03/84 |
| Supervision IX | 6/84 | 9 | 2 | 2.6 | 9/11/84 |
| Supervision X | 5/85 | 6 | 2 | 1.7 | 6/28/85 |
| Supervision XI | 5/86 /e /g | 18 | 3 | 2.6 | 7/17/86 |
| Completion | 5/88 | 11 | 1 | 1.6 | - |
| Total | | | | 18.4 | |

/a The staffweeks spent on supervision of the project were proportionally allocated based on the below.
/b Combined with supervision of Heavy Machinery Project (Loan 1466-KO).
/c Combined with preparation of the First Technology Development Project (Loan 2112-KO).
/d Combined with appraisal of Loan 2112-KO.
/e Combined with supervision of Loan 2112-KO.
/f Combined with preappraisal of the Second Technology Development Project (Loan 2473-KO).
/g Combined with supervision of Loan 2473-KO.

## OTHER PROJECT DATA

| | Original plan | Revisions | Actual |
|---|---|---|---|
| First Mention in Files on Timetable | | | 8/11/75 |
| Government's Application | | | 10/31/76 |
| Negotiations | | | 2/23/79 |
| Board Approval Date | | | 3/22/79 |
| Loan Agreement Date | | | 3/29/79 |
| Effectiveness Date | | | 6/28/79 |
| Closing Date | 12/31/83 | 8/31/85 | |
| | | 6/30/86 | 6/30/86 |

Borrower: Republic of Korea

Executing Agency: Korea Institute of Electronics Technology (KIET)/a
Fiscal Year of Borrower: January 1-December 31

/a Later merged into ETRI

# PROJECT COMPLETION REPORT

## KOREA

## ELECTRONICS TECHNOLOGY PROJECT
## (Loan 1676-KO)

## HIGHLIGHTS

i. In October 1976, the Government of Korea requested the Bank's support to finance the establishment of a research institute in electronics to be called the Korean Institute of Electronics Technology (KIET), to spearhead the Korean electronic industry into advanced semiconductors. Accordingly, in March 1979, the Bank approved a loan of US$29.0 million to finance the foreign exchange portion of a project to build up KIET's activities. Out of the US$29 million, US$5 million was earmarked for research, development and engineering (RD&E).

ii. The objectives of the project were to develop KIET as a central facility in the semiconductor industry, and, accordingly, to (i) provide technological infrastructure of essential production and support services; (ii) assist in training of technical staff of the industry; (iii) lead the industry in acquiring and developing technologies; (iv) carry out RD&E for industry; and (v) explore market opportunities for the industry abroad.

iii. The construction of the semiconductor facility and the installation of the necessary equipment were delayed by over one and a half years, and the facility was ready to fabricate wafers, the major planned output, only in October 1981. Training and research activities were likewise delayed.

iv. In 1983 the Korean industry started to invest heavily in semiconductors. Contrary to expectations, the major corporations decided to achieve self-sufficiency in the major services which KIET aimed to supply. Accordingly, the demand for KIET's services from the private sector fell considerably short of projected plans, and KIET's activities were shifted to participation in government-sponsored projects. As a result, KIET did not become a profit-making, self-financing institution as envisaged at appraisal and remained a government RD&E center depending on government funding. The RD&E portion of the project was not carried out, and the earmarked fund of US$5 million was subsequently cancelled.

v. The Government decided in March 1985 to merge KIET with another research institute in telecommunications and form a new institute called the Electronics and Telecommunications Research Institute (ETRI). The Bank agreed to the merger and to the transfer of KIET's activities from Gumi to Daejoun, and also agreed to transfer the undisbursed amount of the loan from KIET to ETRI.

vi. The project could not sufficiently achieve many of the original objectives, notably the financial profitability and industry-related R&D programs. However, the project may have played an important catalytic role in the electronic industry by proving to the Korean industry that acquiring advanced technologies and capabilities is within their grasp.

vii. The most important lessons to be learned from this experience are the following:

(i) There must be strong support and participation of industry.

(ii) Industry should have a say in the function of basic strategies of the institute.

(iii) The top management of the institute should be industry-oriented and entrepreneurial.

(iv) The legal and financial framework for such an entity should allow the flexibility of a private sector organization.

# PROJECT COMPLETION REPORT

# KOREA

# ELECTRONICS TECHNOLOGY PROJECT
(Loan 1676-KO)

## OVERVIEW

### Introduction

1. This overview is based on the Project Completion Report (PCR) of the Electronics Technology Development Project (Loan 1676-KO) prepared by the Electronics and Telecommunications Research Institute (ETRI), the implementing agency of the Government of Korea. The loan of US$29 million to the Republic of Korea for the establishment of Korea Institute of Electronics Technology (KIET), which later merged into another institute called ETRI, was approved on March 22, 1978. The loan became effective on June 28, 1979 upon fulfillment of the conditions of effectiveness of the loan, and was closed on June 30, 1986, four years after the original plan.

2. The retrospective analysis of the Electronic Technology Project in Korea is of wider interest because the project supported a definite industrial policy in the high technology area--an area in which the Bank can expect increasing involvement in future years. The purpose of this document is to highlight the most important aspects of the project, as viewed by the Bank, in order to derive some useful lessons for future lending. The additional assessment of the Bank complements and sometimes differs from the views expressed by the borrower and is based on a mission to Korea in May 1988 and other information in files at the Bank.

### Project Background and Context

3. Korea has sustained an extraordinary record of economic growth since the 1960s. Given Korea's poor natural resource endowment, this growth was based on the expansion of manufacturing, which grew between 1961 and 1977 at a real rate of 19% p.a. A major impetus to this remarkable growth came from exports, which grew at an average rate of 32% p.a. in real terms.

4. This growth was accompanied by a significant deepening of the industrial structure and diversification of manufactured exports. One of the emerging areas of growth was the electronics industry. This industry was established in the early 1960s as an import-substitution industry based on the assembly of radios and other electronic consumer goods. It gained momentum during the 1970s, spurred by direct foreign investment, joint ventures and the growth of domestic firms. Production and exports increased at a rate of about 50% p.a. between 1970 and 1977, leading the growth of the manufacturing sector. The output of electronics industries in 1977 reached over US$1.7 billion. About two thirds of the output was exported. The industry became increasingly important to the Korean economy. In 1977 it accounted for 11% of Korea's total exports and employed over 140,000 persons.

5. At that time Korea's electronic production consisted primarily of

conventional components (39%), technologically mature, low-cost consumer products such as watches, radios and black and white television sets (33%), assembly of advanced components, principally by wholly owned subsidiaries of large US companies (18%), and production of telecommunication equipment for the domestic market (10%).

6. The Fourth Five-Year Plan (1977-81) of the Government called for continuing emphasis on the electronics industry as a leading industry in Korea's export-oriented growth. The strategy was to focus initially on a few technologies which would allow upgrade of the design and reliability of Korea's existing product mix and at the same time permit entry into new areas. In order to succeed, the strategy called for attracting foreign investment and know-how and for development of domestic infrastructure and design and manufacturing capabilities.

7. KIET was founded by the Government in December 1976 as a government research institute under the Ministry of Commerce and Industry (MCI) to promote and conduct development of the semiconductor and computer system area and lead the effort in the Government's support of the electronics industry. The idea was that in order to succeed in the industrial strategy, the Government, through KIET, needed to provide the industry with the necessary infrastructure and specialized services which could not be provided by each individual companies. KIET was also meant to be the focal point for the initial transfer of intermediate technologies to Korea and provide related on-the-job training. Also, the Government, through KIET, intended to share with private industry the costs and subsequent benefits of research, development and engineering and promote cooperative R&D efforts among Korean firms.

8. The Bank played an important role in shaping the proposed strategy. An industrial sector mission in November 1974 recommended that Korea seriously consider the acquisition of semiconductor technology as a basis for the development of its electronics industry, and that the cooperation of the Government, industry and research institutions was vital for the achievement of this objective. Subsequent Bank involvement in 1975 (as executing agency) in a UNDP-financed Planning Assistance Project helped shape Korea's development thrust in the semiconductor and digital systems industries in the Fourth Five-Year Plan of the Government.

9. In November 1976, the Government requested the Bank's assistance in financing the foreign currency component of a project designed to establish KIET's activities. By March 1977 the project had been explicitly formulated and the amount of the loan requested by the Government was US$29 million.

## The Project

10. The primary objective of the project was to stimulate the development of a technological base in the Korean electronics industry to achieve high growth level. The proposed project was aimed to develop KIET to play a central role in promoting such growth and accordingly to: (i) provide technological infrastructure of essential production and support services, (ii) assist in the required training and technical manpower development, (iii) lead the industry in acquiring and developing semiconductor and system technologies, (iv) carry out RD&E for industry, and (v) explore and develop export market opportunities for Korean electronics industry overseas.

11. The services KIET was to provide to the Korean industry were of broad range. The assumption was that these services would reduce the initial investment requirements of each individual company and facilitate its entry into the electronics area. KIET services were largely expected to be available by early 1980 and included:

(a) Fabrication of wafers for the industry. This activity was supposed to be the major activity and the biggest revenue producer of KIET (66% of services revenues). The assumption was that Korean private companies, such as Samsung Semiconductors (which was already engaged in wafer fabrication) and other companies which would enter this new activity, would produce wafers for simpler devices while KIET would concentrate on more sophisticated products.

(b) Supply of mask-sets for the domestic industry. This service, which was to be needed for wafer fabrication within KIET, was also to be provided to other wafer producers so as to substitute imports and reduce turnaround time.

(c) Provide integrated circuit (IC) designs as tailor-made service for individual firms. This service was expected to enhance the competitiveness of the domestic industry.

(d) Testing services for the industry. At the time KIET was conceived, there were no local facilities for carrying out electrical and environmental testing of semiconductor devices and system hardware. These services were obtained abroad at a considerable expense.

(e) Contract system work. It was envisaged in particular that KIET's pool of qualified personnel would have substantial capability for the design and development of a wide range of microprocessors, minicomputers and other digital systems for use in Korea.

(f) Supplementary services, such as printed circuit boards (PCB), $H_2$ gas, education services, etc.

12. All the above mentioned activities were to generate revenue from the private industry and KIET was supposed to breakeven in its third year of operation. After breakeven net profits would increase, according to plan, annually.

13. Aside from services to the industry, KIET's activities were intended to include RD&E operations. The purpose of this activity was:

(a) to carry out research projects for the development of products, processes and systems in the electronics industry;

(b) to carry out research costs for work conducted within KIET's facilities; RD&E funds were not to finance the costs of in-house research conducted by private industry;

(c) to carry out projects sponsored by either industry or KIET. With regard to KIET-sponsored projects, however, broad industry

interest in the end result of the project had to be established to ensure that research work at KIET was closely tied to industry goals of the RD&E project for which it was purchased.

14. According to the project financing plan, the Bank loan was expected to provide US$24 million for the development of KIET (the foreign currency part of physical facilities plus part of the technology items) and a loan of US$5 million for the foreign currency portion of the RD&E program.

Implementation and Operation

15. The Government selected for the project a site in Gumi, a town some 200 km from Seoul. The Government hoped to attract into this area firms from the electronics industry so that it would become a center for Korea's electronics activity, with KIET as a focus. At the time KIET started its building activities in Gumi, several electronics plants were already established there, most of these in assembly operations, none in research activities.

16. Construction of the semiconductor building, containing the "clean area" in which research in semiconductor and wafer fabrication were to be carried out, started to slip at an early stage. This segment of the project was on the critical path for the project as a whole since the various proposed services to industry and R&D could only start once the clean area facility was available. However, the semiconductor building was completed, only in April 1981, 18 months behind schedule. Equipment was installed by the end of September 1981, some 20 months behind original schedule. In retrospect, these delays may have been a very important factor in the development of the project. When major Korean electronics firms decided in 1982 and 1983 to invest heavily in semiconductors, KIET did not have a leading technological edge and its wafer fabrication capabilities were not considered reliable enough by the industry.

17. In 1982 and 1983 the Korean industry started to invest heavily in semiconductors. Contrary to the original assumptions, the major corporations decided to achieve self-sufficiency in the major services which KIET aimed to supply. Accordingly, the demand for KIET's services from the private sector fell considerably short of projected plans. At the same time the Government decided that electronics was a priority industry, started to direct and finance national projects in electronics and KIET's activities were shifted to participation in government-sponsored projects. As a result, KIET did not become a profit-making, self-financing institution as envisaged at appraisal and remained a government RD&E center dependent on government funding. The RD&E portion of the project was not carried out, and the earmarked fund of US$5 million was subsequently cancelled.

18. During the period 1979 to 1985, KIET rendered the following services to industry:

a) Wafer fabrication was carried out in 1983 and 1984 on a small scale but the products were not sold to the local industry but, rather, to a U.S. firm.

b) Mask sets were provided to industry. This activity which initially was planned to be a marginal one in terms of

revenue turned out to generate 35% of revenue derived from services to the industry.

c) Testing activities were performed on a small scale.

d) KIET provided $H_2$ gas to the neighboring GoldStar plant of bi-polar memories.

e) KIET provided tailor-made training services to the industry. The activity was carried out on a modest scale until 1984 and then terminated.

f) KIET has also provided, though not as a revenue-producing service, on-the-job training to engineers who came to KIET to participate in government sponsored projects.

g) IC design and system work as well as R&D were carried out through the whole period not as services to the industry but rather as government sponsored activities which were financed on a cost plus basis.

19. Over the years, most of KIET's (and later ETRI's) revenue came from the Government (including the item Project Revenue on the income statement in Annex 4 of PCR). Only some 15% of the revenues came from private business or exports. KIET, throughout the project period, did not manage to breakeven and accumulated a loss of over Won 6.7 Billions.

20. As early as July 1980, the Government had considered to merge KIET with two other organizations. This proposed change was the result of a decision to reorganize all the research institutes under the Ministry of Science and Technology (MOST). The Bank initially viewed the proposed merger of KIET unfavorably and conveyed its concerns to the Government at various occasions. The Bank's main concern was the lack of commonality between KIET as an industry-oriented entity and the other government-owned research institutes.

21. The Government decided, finally, in March 1985 to merge KIET with another research institute in telecommunications and form a new institute called the Electronics and Telecommunications Research Institute (ETRI). It was established in a different location and consequently KIET's original facility in Gumi was sold to a private Korean company. The Bank agreed to the merger and to the transfer of KIET's activities from Gumi to Daejoun, and also agreed to transfer the undisbursed amount of the loan from KIET to ETRI.

Project Achievements and Impact

22. Until 1982 the rapidly growing electronics industry in Korea practically ignored semiconductors. The shift occurred as a result of worldwide shortages in semiconductors, which increased the prices of semiconductors and also severely impaired production of consumer goods. It was then that the leading companies in Korea decided to vertically integrate and move aggressively into semiconductors as well. Accumulated fixed investments in semiconductors in Korea from 1974 to 1981 amounted to about US$200 million. In 1983 alone, investment totaled US$300 million, then climbed to over US$400 million each year for 1984, 1985 and 1986. As a

result, Korean firms managed to achieve a prominent position among the world manufacturers.

23. It is difficult to ascertain to what extent KIET and later on ETRI contributed to the Korean thrust into semiconductors. It is clear that the thrust has been industry led and not Government led. On the other hand, the role of KIET in pioneering research in semiconductors and proving that Korea can fabricate wafers successfully is undeniable. As one of the managers of the Korean semiconductor industry puts it, "KIET gave us a shot in our arm." To what extent the industry would have decided to go heavily into semiconductors without KIET is a question to which there can be no definite answer. Conversely, to what extent the manufacturer's decision to go-it-alone was a result of the inability of KIET to deliver reliably and on time is also not answerable. These two different views, which are not mutually exclusive, can be heard from knowledgeable people inside and outside Korea.

24. Perhaps a balanced view of the project (and KIET's) assessment would be that it played an important catalytical role but certainly not a leadership role in the development of semiconductors in Korea as was originally envisaged. KIET's pioneering efforts in 1979-81 in the acquisition and development of semiconductor technologies and the demonstration effect it had in Korea, and the training provided by KIET to personnel from private entry probably in themselves justify the establishment of KIET.

25. There are possibly two factors that explain the inability of KIET to assume a leadership role in the sector. First, while preparing this project, the Bank underestimated the drive, dynamism and risk taking attitude of the Korean private sector. Once the private sector made the decision to go into semiconductors, it did so in a way which dwarfed KIET and, as a result KIET's services became increasingly less attractive. In addition, the Bank also did not anticipate the problems of getting the Korean industry to launch into a cooperative venture given their fiercely competitive nature and a strong sense of individualism. This proved to be one of the main obstacles to getting KIET's R&D activities off the ground. Industry cooperation and support are critical for an organization like KIET to succeed.

26. Adding to the problems was the lack of agility on the part of KIET's management and the inability of the Bank to take early corrective action. The two problems mentioned above had become evident at an early stage of project implementation and the Bank urged the Government on numerous occasions to instill more dynamism and private sector orientation into KIET's management. But these efforts did not bear fruit. It can be argued that in a project like this, it should not be surprising that things do not develop as originally envisaged. But what is required on the part of the Bank is willingness and decisive action to reshape the project.

27. In spite the industry's achievements the success of the Korean industry in semiconductor is still not clear. The industry is characterized by short life cycle products and by increasing R&D costs. So far, the strategy of Korea was to follow the leaders and save on R&D in order to compensate for lower effectiveness due to being a latecomer. This strategy might not work in the future and the Government and industry might look ahead to the future strategy and the role of ETRI. The Government should probably do well to study the successes and failures of KIET in adhering to its original strategy as stated in the appraisal report. Some of the premises and conclusions in this report might be even more relevant

to the present situation.

28. The successes or failures of the Electronics Technology Project can only be judged against its objectives. If judged narrowly against the original objectives of financial self-sufficiency or of completing the R&D work program as stated in the appraisal report, the project could be said to have failed in those areas. In retrospect, some of the objectives, for instance, KIET revenue and profit targets may have been non-realistic.

29. However, in a much broader context, taking into consideration the Korean semiconductor industry's big move in terms of investment in 1983/84 and the huge quantum leap in terms of technological level from 1980/81 to 1983/84, it could be said that the project and KIET may have played an important catalytic role. In fact, the most single important achievement/success of the project was to prove to Korean industry in 1981/82 that Korea, through KIET, did acquire wafer fabrication capability and that advanced semiconductor technologies were within their grasp.

30. The most important lesson that can be learned from this experience is the need to enhance the chance of success for such ventures to ensure the presence of the following factors:

(i) There must be strong initial support (including financial support) and participation of industry. In order to ensure the cooperation, industry should be represented in the management of the venture or, at least, be in a position to influence decisions. It is also important for an industry service/support organization such as KIET to have a close working relation with the Ministry with direct jurisdiction over the subsector concerned.

(ii) The top management of the entity involved must be industry-oriented and entrepreneurial to be able to deal effectively with industry as well as Government.

(iii) The legal framework for such an entity should provide its management with the flexibility and agility of a private sector organization.

31. In the case of a Bank project in a high-tech area which is characterized by technologies with short life-cycles and a rapidly changing industrial environment, the Bank should be prepared to monitor constantly the changing environment, the development of the project and the original objectives and business plan in order to be able to respond quickly by correcting deviations and/or changing objectives and financial plans. For example, in a high-technology area, a facility suitable for research purposes can become obsolete for the original purposes. In such a case it is important to take into account during project design, a possibility of the disposition of a Bank-financed facility. In view of this, the location of the project facility is particularly important. The Bank would also need access to technical experts in those areas in order to provide the Bank and the borrower the needed technical expertise and applied scientific evaluation.

PROJECT COMPLETION REPORT

KOREA

ELECTRONICS TECHNOLOGY PROJECT
(Loan 1676-KO)

# I. INTRODUCTION

1.01 The Korea Institute of Electronics Technology (KIET), a government-donated institution established in December 1976, conducted the technological development of the semiconductor and computer systems areas in order to promote the development of Korea's electronics industry. For this purpose, the Bank provided KIET with the Electronics Technology Project (Loan 1676-Ko) which was financed with the Bank loan of US $29 million. The project has been, in general, adequately carried out in order to attain its objectives.

1.02 However, under the government's decision on the merger of KIET at Gumi estate and Korea Electrotechnology and Telecommunications Research Institute at Daedog Science Park, a new institute was established as the name of Electronics and Telecommunications Research Institute in 1985, and accordingly succeeded this loan project. Therefore, the names of all ETRI's hereafter mean the former KIET and/or ETRI. Besides, the facility at Gumi established under this project was transfered to the private sector in April 1986, and a new semiconductor research facility is under construction with the target of its completion in September 1987.

# II. PROJECT PREPARATION AND APPRAISAL

## Preparation, Appraisal and Negotiations

2.01 In November 1976, the Government of the Republic of Korea (ROK) requested Bank assistance to finance a project that would promote and assist the technological development of the Korean electronics industry. The Bank played an important role in shaping the project. The industrial sector mission of November 1974 recommended that Korea should seriously consider acquisition of the semiconductor technology as a basis for development of its electronics industry, and

the cooperation of Government, industry and research institutions was vital for the achievement of this objective. Subsequently, in 1975-76, the Bank acted as an executing agency for a UNDP-financed Planning Assistance Project, which included a review of the prospects of the electronics industry and suggestions for policy formulation in this sector over the period of the 1977-81 Five Year Plan ; the Plan emphasizes industry's new development thrust in the direction of the semiconductor and digital systems areas.

2.02 The Government of the ROK applied to the Bank for the project with $20 million of foreign cost in March 1977. A project preparation mission visited Korea in July 1977 to review the project proposed by the Government to develop ETRI, and recommended that ETRI should be rediredted from a relatively isolated research institution to a service-cum-RD&E organization catering to and working directly with industry. The second project preparation mission in May/June 1978 appraised a $52.8 million project with a foreign cost element of $27.7 million. The appraisal was completed in November 1978.

2.03 Negotiations for the loan was completed in Washington in February 1979. The Bank's Board approved a loan of $29 million to ETRI with a Government Guarantee in March 1979. The Loan agreement was signed on March 29, 1979.

Project Objectives

2.04 The objective of the project was to promote the technological development of the Korean electronics industry through :

(a) the further development of ETRI and the Upgrading ;
(b) the carrying out by ETRI of programs of technology aquisition, training and manpower development ; and
(c) the carrying out in ETRI's facilities of a program of research, development and engineering for the benefit of the electronics industry in Korea.

The Program and Project

2.05 The project for the period 1979 - 82 consists of the following parts :

Part A: (1) Construction and equipping of a semiconductor building, an administrative and systems activities building, a training center, a power sub-station with an emergency power generating system, a uility plant with air handling and chilling equipment, a dionized water plant and a pure hydrogen generating plant, including the provision of land therefor.

(2) Construction and furnishing of housing and dining facilities for ETRI's staff, including the provision of land therefor.

Part B: (1) Carrying out of a program of academic, on-the-job and overseas staff training, including the provision of educational materials, staff attendance at international conferences and seminars and invitations of foreign experts to provide ETRI with required technical assistance and to conduct short workshops and seminars at ETRI's facilities.

(2) Carrying out of a technology acquisition program consisting of the purchase of technology through licensing or other arrangements with companies and institutions engaged in electronics and other related activities.

Part C: (1) Carrying out at ETRI's facilities of a research, development and engineering program designed to adapt proven technologies, upgrade existing product capabilities and develop new products in the electronics field for the benefit of the electronics industry in Korea. The program consists of the carrying out of specific subprojects for the development of products, processes and systems up to the final development stage.

(2) The provision of technology, equipment, speciality materials, experts' services and overseas training required for the proper carrying out of the above subprojects.

Covenants

2.06 The status of compliance with Loan and Project Agreements is at Annex 1. Performance with respect to compliance with covenants has generally been good, though poor in some respects of the area of operation of RD&E program. The reason for this is discussed in the relevant section of this report.

## III. PROJECT IMPLEMENTATION

Loan Effectiveness and Project Start-up

3.01 All the conditions for loan effectiveness were met within the appropriate period and the loan was declared effective on June 28, 1979.

Project Revision

3.02. The project did not undergo any substantial revision during 1979-82. There were, however, the following changes :

(a) ETRI's succession of the project with the merger of KIET at Gumi estate and KETRI at Daedog Science Park ;

(b) Cancellation of the use of RD & E fund ; and

(c) Transfer of the Gumi facilities to the private sector.

Implementation Schedule

3.03 The original schedule for construction of the various component works of the project provided for project completion by September 1979. However, the construction of the semiconductor building was completed in April 1981, 18 months behind the original schedule, and that of computer building, in May 1982, two years and 8 months late. The delay in project execution was caused by the following factors :

(a) the semiconductor building, as the first construction in Korea, needed more careful review of the building design by Rasmussen Ingle Anderson Corp. in the USA and well-experienced expert's consulting due to its speciality :

(b) the delay in installation of the facility-supporting equipments for mechanical works due to long-lead time for their procurement with foreign expenditure ; and

(c) the budget shortage for the computer research building, resulting in its completion with the additional budget of about 500 million won in 1982.

The delay in construction of semiconductor building was to a great measure contributory to the delays in delivery and installation of research equipment, whose installation, in most cases, were delayed until the end of September 1981.

3.04 The original schedule for overseas training and foreign invitation programs was to be conducted for the period of 1979 to 1981. In execution, these training and expert invitation programs have been continuosly carried out until 1986. A comparision of the original appraisal and actuals on these programs is given below :

Table 1: TRAINING & EXPERT INVITATION
(Unit: Man-months)

| Description | Appraisal Estimate | | Actuals | |
|---|---|---|---|---|
| | Number | man-months | Number | man-months |
| Training | | | | |
| . Semiconductor | 65 | 390 | 54 | 316 |
| . Systems | 70 | 420 | 46 | 378 |
| . Management | 8 | 48 | 5 | 13 |
| Total | 143 | 858 | 105 | 707 |
| Conference | 25 | - | 63 | - |
| Expert Invitation | | | | |
| . Semiconductor | 32 | 32 | 10 | 46 |
| . Systems | 32 | 32 | 21 | 11 |
| . Management | 17 | 17 | | - |
| . Technical Advisor | 1 | 20 | 1 | 17 |
| . Facilities | 3 | 1 | 2 | 23 |
| Total | 85 | 104 | 34 | 97 |

The training and expert invitation programs were somewhat poorly progressed until 1981 because of (i) the heavy preasure on construction of semiconductor building and procurement of research equipment, and (ii) the difficulties in locating proper training institutions and suitable experts in selected technology areas who were willing to provide such services. However, generally speaking, these programs have been adequately carried out to attain the objective of up-grading of ETRI's technological base in the areas of semiconductor and computer system.

3.05 The technology acquisition program for 1980 was first prepared in November 1979 and submitted to IERD, but thereafter no further progress was made. In May 1982, a technology transfer agreement with VLSI Technology, Inc. (VTI) in the USA was made in order to acquire the silicon gate NMOS technology of 32K/64K ROM with the terms and conditions of provision to VTI of the wafers processed in return for royalty as the technology fee. With this technological assistance, ETRI successfully established 32K/64K ROM production technology, first in Korea. In November 1985, a joint development agreement on super-mini computer system was made with American Information Technology, Inc. in the USA with the terms and conditions of payment of one million dollars of technology fee. Under this agreement, 16 members of ETRI staff are under training for the acquision of VLSI design, and hardware/software technologies design of computer system for one year to June 1987.

3.06 The RD&E program was to finance both ETRI and industry-sponsored projects carried out in ETRI's facilities for the development of products, processes and systems up to the final development stage. To ensure that research work is closely related to industry goals, the major portion of the research work carried out in ETRI's facilities was required to have an industry sponsor. As the RD&E program required of the above terms and conditions, any agreement between ETRI and industry for such project had not been reached by 1981 due to the industry's uncertainty of semiconductor industry. However, recognizing the importance of semiconductor industry, big companies began investing enormous amount of funds on production and research facilities for the self-development of semiconductor and computer related products since 1981. Subsequently, the Ministry of Science and Technology establish a national research system in order to stimulate product oriented research and development in the joint efforts of government-supported institutes and the industry since 1982. Thereafter, ETRI began catering its research activities to the national program and the RD&E program became difficult to be carried out.

Procurement

3.07 Procurement of equipment was executed by ETRI in accordance with the procedures established by the World Bank Loans. The majority of equipment was originally planned to be installed in the early quarters of 1980. However, in actuality most of the equipment was contracted in the 3rd quarter of 1980 and installed in September 1981, one and half years behind the original schedule. The poor progress of procurement was mainly caused by (i) the delay in construction of semiconductor building, and (ii) the adjustment of some items of equipment due to some changes in research programs.

3.08 Some of additional equipment was procured for the development of 32K / 64K ROM technology in 1982, and for the conversion of 3" bipolar line to 4" line in 1984. In 1986, seven items of additional equipment were procured in order to improve such services as mask making and testing to the industry.

Project Cost

3.09 A comparison of the original appraisal with actual project cost is given below :

Table 2: PROJECT COST
Unit: $000 (Local = Won million)

| Description | Appraisal Estimate 1/ | | | Actual Cost 2/ | | |
|---|---|---|---|---|---|---|
| | Local | Foreign | Total | Local | Foreign | Total |
| (1) Construction & Equipment | | | | | | |
| . Construction | 4,200 | 1,780 | 10,440 | 6,005 | - | 8,060 |
| . Supporting equipment | 800 | 5,360 | 7,010 | - | 5,841 | 5,841 |
| . R&D equipment | | 11,690 | 11,690 | - | 13,766 | 13,766 |
| . Installation, etc. | 570 | - | 1,190 | 733 | - | 984 |
| . Sub-total | 5,570 | 18,830 | 30,330 | 6,738 | 19,607 | 28,651 |
| (2) Technology Program | | | | | | |
| . Training | 50 | 2,070 | 2,170 | - | 2,393 | 2,393 |
| . Expert Invitation | 100 | 770 | 980 | - | 940 | 940 |
| . Tech. Acquisition | - | 1,660 | 1,660 | - | 1,000 | 1,000 |
| Sub-total | 150 | 4,500 | 4,810 | - | 4,333 | 4,333 |
| (3) Contingencies | 850 | 4,090 | 5,840 | - | - | - |
| Total | 6,570 | 27,420 | 40,980 | 6,738 | 23,940 | 32,984 |

1/ The exchange rate used at appraisal was $1 = 485 Won.

2/ The exchange rate for actual cost is at Annex 2.

3.10 The RD&E program is excluded in the above table due to non-execution thereof. The local costs are the investment on the Gumi facilities for 1978-84, and the foreign costs are the investments on equipment and technology programs financed from the Bank loan for 1979-86.

3.11 The local costs on completion of construction is 6,005 million won v.s. 4,200 million won at appraisal. The major reason for overruns is caused by the increase of construction costs due to-the delay in construction of semiconductor building.

Disbursement

3.12 The estimated and actual annual cumulative disbursement of the loan is as follows :

**Table 3: CUMULATIVE DISBURSEMENT**
**($ Million)**

| Bank Fiscal Year | Appraisal Estimate | Actuals 1/ | Actuals as Percent of Appraisal Estimate |
|---|---|---|---|
| 1979 | 13.3 | 0.047 | - |
| 1980 | 21.9 | 7.949 | 36 |
| 1981 | 27.0 | 14.710 | 54 |
| 1982 | 29.0 | 17.115 | 59 |
| 1983 | | 20.397 | 70 |
| 1984 | | 20.585 | 71 |
| 1985 | | 20.681 | 71 |
| 1986 | | 22.638 | 78 |
| 1987 | | 23.941 2/ | 83 |

1/ The slow disbursement was caused by delays in procurement of equipment and by non-execution of RD&E program.

2/ Final disbursement effected on January 30, 1987

Loan Allocation

3.13 Original, revised and final allocation of the loan are :

**Table 4: LOAN ALLOCATION**
**($ million)**

| Category | Loan Allocation Original | Revised Allocation 8/20/82 | Cancellation 8/30/85 | Final Allocation |
|---|---|---|---|---|
| 1) Equipment | 17.7 | 19.6 | - | 19.6 |
| 2) Expert's Services for Semiconductor Facilities | 0.25 | 0.25 | 0.036 | 0.214 |
| 3) Training, Experts' Service and Technology procurement | 4.15 | 4.15 | - | 4.15 |
| 4) RD&E program | 5.0 | 5.0 | 5.0 | - |
| 5) Unallocated | 1.9 | - | - | - |
| Total | 29.0 | 29.0 | 5.036 | 23.964 |

3.14 In August 1982, the Bank agreed to use the unallocated funds for procurement of equipment, taking in account the increased cost of contracted amounts of equipment. In accordance with discussions between the representatives from the Bank and ETRI in Washington in July 1985, the Bank agreed to cancel the use of the $5.0 million under category 4 and the $36 thousand of the remaining fund under category 2 in August 1985.

Operation

3.15 Semiconductor processing facility under the project was brought into operation in September 1981. Henceforth, ETRI was placed on a position to provide the industry with such services as wafer fabrication (bipolar and MOS), mask fabrication, IC testing, reliability test, etc. With the completion of computer building in May 1982, system-related research activities began to be carried out actively. However, computer production project including printed circuit board was given up and accordingly some items of PCB equipment procured were sold to the industry.

3.16 With the enforcement of a national research system by MOST since 1982, ETRI placed more emphasis on the conduct of national research programs than on providing the industrial services. Major projects like development of VTR IC's and 8 bit microprocessor/microcomputer, development and ditribution of personal computer, development of 8/16 bit CP/M machine and 16/32 bit UNIX computer, etc. were carried out by the joint efforts of ETRI and the industry.

3.17 Since 1981, big electronic companies like Samsung, GoldStar and Hyundai began to invest in the semiconductor technology in order to take some portion of the newly growing semiconductor market, and the Korean government also supported them for a breakthrough of electronic technology development in Korea. In this regard, at the end of 1983, it was reviewed that ETRI should lead the industry through development of more advanced technologyies with up-grading the semiconductor facility and transfer its semiconductor facility at Gumi to the private sector for more economic utilization of the facility. Accordingly the transfer of the Gumi facility was proceeded with for bidding, and a transfer contract was awarded with Daewoo Telecommunications in 1984. However, due to Daewoo's waving of the transfer agreement in August 1984, the transfer problem was held back. In January 1986, the transfer of the facilities was rebidded, and completly transfered to GoldStar Semiconductor in April 1986.

3.18 In the end of 1984, to meet the information society in the 2000's, the Korean government decided to establish a new institution with the merger of

the two institutes ; KIET at Gumi estate and KETRI at Daedog Science Park. In March 1985, Electronics and Telecommunications Research Institute was established with a future-oriented research system-to undertake national research and development on advanced information technology integrating the areas of telecommunications, computers, automations and semiconductors. Thereafter, ETRI began to carry out the custom semiconductor IC design activities including telecommunication IC's.

Performance of Consultants, Contractors, Suppliers and Borrower

3.19 In accordance with the provision of Article 2.02 to the Project Agreement, a technical advisor was empolyed in order to assist ETRI in carrying out of technology programs and RD&E programs. The contract was entered into in October 1979 for two years and three times extended to June 1986 upon the extension of the loan project. The technical advisor had worked at ETRI U. S. Office as a part-time job, and visited ETRI when necessary. The performance of the technical advisor overall was adequate. He effectively assisted ETRI in preparing bid documents, specifications, evaluation of bids for procurement of equipment, and gave suitable recommendation on training and expert invitation programs.

3.20 As agreed under the provision of Article 2.03 to the Project Agreement, a semiconductor facility expert was empolyed for two years starting in September 1979 in order to give day-to-day supervision on construction of semiconductor building. The performance of the expert was generally adequate, and he also assisted ETRI in procurement and installation of semiconductor equipment, and start-up operation of the semiconductor facility.

3.21 The performance of local civil engineering contractors for building and supporting facilities was generally adequate, though the delay in construction of semiconductor building. The research and supporting facility equipment contractors delivered and installed their equipment without any critical problem on execution of the contracts.

# IV. OPERATING PERFORMANCE

4.01 The actual services to industry such as wafer fabrication, mask making, IC testing, hydrogen gas, training for engineers from industry are given below :

Table 5: SERVICES TO INDUSTRY
(Unit : Won millions)

| Service Revenues | 1979 | 1980 | 1982 | 1983 | 1984 | 1985 | 1986 |
|---|---|---|---|---|---|---|---|
| Wafers | - | 9 | 5 | 99 | 56 | - | - |
| Masks | 51 | 35 | 42 | 78 | 134 | 435 | 631 |
| Testing | 31 | 43 | 8 | 14 | 16 | 884 | 1,777 |
| H2 Gas | - | - | 34 | 82 | 212 | - | - |
| Training | - | 26 | - | 44 | 70 | - | - |
| Total | 82 | 113 | 89 | 317 | 488 | 1,319 | 2,408 |

At appraisal of the project, the goal of ETRI was to become self-supporting with the service incomes plus RD&E revenues since 1984. However, the actual services to the industry were carryed out so poorly that the comparision with that at the appraisal was not made. The reasons on poor performance of the industrial services were caused by (i) late start-up operation of semiconductor facility due to the delay in construction and equipping of the semiconductor facilities, (ii) demand reduction of wafers from the industry due to big companies' participation in the semiconductor industry since 1981, and (iii) concentrating ETRI's efforts on national research programs instead of the industrial services since 1982. However, the supply of mask-sets and testing to the industry has been adequately carried out to meet the demand thereon from the industry. In the training of industry personnel, the number of technical manpower required for the industry had been trained through establishment of courses at ETRI such as design and process technology of semiconductor, micro processor applications, UNIX, etc.

4.02 The performance of research and development in the areas of semiconductor and computer systems was adequately carried out, though the RD&E programs with the assistance of the Bank loan was not proceeded with. The research activities may be described in the following three phases :

(a) First Phase (1978 - 1981)

During this phase, ETRI developed the technological base through recruitment of superior staff and foreign training of its engineers, while it was busy with building construction and equipment procurement. Development of basic technologies in the areas of semiconductor design and process, and partial development of computer hardware and software were carried out. Especially, a traffic control system for Seoul City was successfully developed and installed in 1981, and its technology was transfered to Oriental Pricision Co.

(b) Second Phase (1982 - 1984)

With the start of a national research program since 1982, in the semiconductor area, ETRI acquired its development capabilities of advanced semiconductor technology through development of basic CAD technology, fine line mask technology, epitaxial layer growing technology, quality assurance and control technology, etc. In the joint efforts with the industry, ETRI developed bipolar I2L process technology and 5 items of VTR IC's using its process, and silicon gate NMOS/CMOS process technology and 8 bit uP/uC IC using its process. Especially the development of VTR IC's was worthwhile because Japanese chip suppliers had been hesitant to supply those IC's to Korean set makers. And as in-house projects, pilot production of 32K/64K ROM wafers was successfully carryed out in 1982 - 83, first in Korea, with the technical assistance from VTI in the USA, and semiconductor sustaining technology was started to be devloped in 1982, which resulted in acquiring semiconductor production technology.

In computer area, by virtue of computer standardization in microsystems, system development with standard components was performed by using system integration and software porting technology. For the purpose of development of Korean-type micro computer systems, development of 8/16 bit u-processor based CP/M machines, personal computers for education and 16/32 bit UNIX systems were carried out in the joint efforts with the industry. Especially 16/32 bit UNIX system technology was transfered to the participant companies.

(c) Third Phase (1985 - 86)

With the establishment of ETRI, in order to meet the information society in the 2000's, the areas of electronics and telecommunications, which will play the key role as the infrastructure in the society, are required for the systematic technology development integrating computers, telecommunications, automation control, semiconductor, software, etc. For this purpose, ETRI started the technology develpment of computers, automations, custom VLSI's and next generation semiconductors.

In computer area, in order to develop computer systems for the national administration information services, the required technologies are under development, and research and development projects for obtaining the abilities to develop knowledge processing computer systems using the artificial intelligence technology have been proceeded. In 1986 development of multiprocessor computer system started for developing supermini computer system. In automation area, for the purposes of development of the technologies of standardized distributed control systems and provision of technological background with the industry to have the advanced structures of industrial manufacturing systems, ETRI started development of a manufacturing information processing system, graphic workstation, and instrument and control technologies.

In semiconductor area, with the creative conception and technology based on the technology development capabilities accummulated by the second phase,

ETRI started the carrying out of development of custom VLSI technologies for telecommunication IC's, computer systems, etc., development of memory devices including 4M DRAM, development of design automation system, development of next generation semiconductor (GaAs, etc.), development of process equipment and materials, and surface analysis technology.

## V. FINANCIAL PERFORMANCE

5.01 At the appraisal of the project, ETRI was to become self-surporting with the service incomes and royalty revenues within five years. However, as seen in section of Operating Performance, the industrial services were poorly carried out and the RD&E progran with the Bank loan was not executed completely. Accordingly, the comparison of the actual financial performance with that at the appraisal was not made, and the actual financial statements are attached hereto as Annexes 3, 4 and 5.

5.02 The numbers in the financial statements in 1985-86 showed much increases due to the merger of two institutes. The research costs had been mostly supported by the MOST by 1984, but since 1985 the research costs are being in great portion by the Korea Telecommunication Authority (KTA) besides the MOST. A new semiconductor research facility is under construction with the finanicial support of KTA aiming at the completion of its construction in september 1987.

5.03 The transfer of the Gumi facility to the private sector was, as seen in section of Operation, completely ended in April 1986. The transfer price was 16,865 million won in total : 15,365 million won for assets and 1,500 million won for bid premium. Of the transfer price, the IBRD loan liability equivalent to USD14,211 thousand was assumed by Gold Star Semiconductor Co., the Assignee, and the balance of 4,217 million won was paid in cash.

# VI. INSTITUTIONAL PERFORMANCE

## Organization and Management

6.01 The former KIET was established in December 1976 as an outgrowth of the semiconductor development and systems units in Korea Institute of Science and Technology. A suitably qualified president was designated in November 1977, and ETRI was expected to be run as the service-cum-RD & E organization since 1984. A seperate IBRD project management unit was not created, but the management of the IBRD project was carried out by the project development group.

2.02 While building construction and equipment procurement were still on progress, a new president was designated in February 1981, and ETRI was reorganized for more effective management towards the RD & E-oriented operation of the semiconductor facility instead of the production services for industry, and accordingly ETRI's efforts has been emphasized on carrying out the national research programs to meet the government's goals for science and technology development since 1982.

6.03 ETRI's performance has been, in general, adequate even though the self-supporting goal was not attained. However, many difficulties in management of the project have been encountered due to the number of changes of managers, the transfer of the Gumi facility to the private sector, and the merger of two institutes (KIET and KETRI). Effectively coping with these diffilculties, ETRI had contributed, to a great measure, to promoting and stimulating the technology development of Korea industry in the areas of semiconductor and computer systems.

Staffing, Recruitment and Training

6.04 In order to lead Korean industry with advanced technology capabilities in the related areas, ETRI was required to recruit a superior staff and train them. During the period of the project, recruiting the superior staff was not easy because Gumi estates had not been developed as a Silicon Valley in Korea as planned due to the industry's negative response on the move to the Electronics Industrial Complex at Gumi, and superior manpower preferred to enter research institutions and/or pay-well companies in Seoul or its vicinity. Besides, some of the superior staff were lost to academic institutions and/or the industry due to the long period of proceedings with the transfer of the Gumi facility to the private sector since the end of 1983.

6.05 The training program for ETRI engineers was originally to be carried out in the three major phases : (i) basic training at KAIST, other Korean universities, and courses at ETRI itself ; (ii) overseas group and fellowship training under formal training schemes in academic and industrial settings ; and (iii) on-the-job experience in overseas companies in selected technologies. Overseas training programs in the above (ii) and (iii) have been adequately carried out, as stated in the section of the Implementation Schedule. Courses at ETRI such courses as u-processor applications, computer languages, micro computer software, semiconductor design / process, etc., had been adequately carried out for ETRI staff as well as engineers from the industry. Basic training at KAIST has been carried out since 1981 with the operation of part-time courses for the engineers from research institutions.

Accounting System

6.06 At the appraisal of the project, ETRI was to establish a separate financial department for developing an appropriate cost accounting system in view of the complex financial accounting requirements related to ETRI operations and RD & E. However, though a financial department was established in the end

of 1980, a cost accounting system was not made because ETRI gave its major efforts on national research programs instead of the industrial services. Accordingly, the government's budgeting and accounting system has been continuously applied.

Audit

6.07 In accordance with the provision of Article 4.02 of the Project Agreement, the local accounting firms have audited ETRI's accounts since 1980 and the audited accounts have consistantly been submitted to the Bank within the covenanted time of four months after the end of each fiscal year.

6.08 ETRI established an internal audit system, and a fully qualified internal auditor was appointed in 1978. His replacements were generally qualified, and the system has worked well to meet efficency and improvement of institutional operation and management, especially seeking prior prevention of the expected problems.

## VII. PROJECT JUSTIFICATION

Project Achievement

7.01 The project in general achieved the objectives set out at appraisal through the provision of the industrial services and carrying out the national research program, though the RD & E program with the Bank loan was not carried out. The supply of mask-sets and testing service has contributed to import substitution, reduction of turnaround times, cost-saving, and improvement of product quality and reliability for Korean semiconductor industry. Through the successful conduct of the national research program since 1982, especilly in the joint efforts of ETRI and the industry, the project has greatly contributed to promoting the development of a technological base in the Korea electronics industry.

Consequently, Korea is now enjoying import substitution and export increase of electronic products and devices through the localization of them. Besides, the training of industry personnel at ETRI facility has greatly contributed to the development of the technological base of Korean electronics industry, and also those who was trained at ETRI have also played the important roles for establishment of the private training centers in the areas of semiconductor and systems.

7.02 In the semiconductor area, design and process technologies of VTR IC's developed with the joint efforts with the industry was successfully transfered to the two participating companies. Thereafter, VTR IC's are now under commercial production for import substitution. ETRI has, through development of silicon gate NMOS / CMOS technologies, effectively contributed to stimulating the industry's vigorous investment on semiconductor production facilities and the indusry's technological base. Consequently, the industry developed 64 K DRAM in 1984 and 256K DRAM in 1985, which are now under commercial production, and also successfully developed the prototype of 1 M DRAM in 1986. In addition, based on the research and development experiences in the meantime, ETRI and three big companies started the development of submicro meter VLSI technology on a large-scale national program in 1986, which is expected to bring out a productive 4 M DRAM within two years.

7.03 In the computer area, ETRI promoted a computer mind in Korea through the successful development and distribution of personal computer for education in joint efforts with five local firms. 16 bit UNIX system technology was successfully put into commercial production at the participating companies in 1984, and also 32 bit UNIX systems technology developed in 1986 will be transfered to the participating companies in 1987. Subsequently, the industry is now accelerating local production of small & medium size computers. Furthermore, with the use of the accummulated technologies in the past years, in 1986 ETRI started the development of super-mini computer system technology, knowledge processing computer systems, FA network systems technology, instrument and control technology, etc., effectively to assist the realization of ISDN by the year 2000.

Project Spin-offs

7.04 As spin offs from the project, ETRI obtained such research results as design drawings, masks, design tools, etc. of semiconductor devices, and prototypes, development documents, etc. of PCM, P/C and 16/32 bit computer systems.

Least Cost Solution

7.05 ETRI has overall adopted the least cost policy in every step of planning, review and execution of research programs, not to mention building construction and equipment procurement at the early stage of the project. However, the delay in construction of the semiconductor building resulted in cost increase.

Rate of Return

7.06 Since ETRI has been continuously involved in the research and development programs with the assistance of the government, the rate of return could not be applied. However, the small amount of royalty from technology transfers to the industry was used for payment of staff incentive and the cost of basic in-house research programs. Besides, the project attained indirect investment effects like import substitution and foreign export through localization of the semiconductor and computer products with the help of the services and joint development programs provided by ETRI during the period of the project.

## VIII. BANK PERFORMANCE

Overall and Specific Performance

8.01 The performance of the Bank in respect of the project was adequate in general. The Bank's contribution at the stage of preparation was a positive,

and had a material impact on the decision of the Korean government to establish the former KIET as a government-supported institution which would stimulate and support the electronics industry's drive into the new areas of semiconductor and system technology.

Supervision

8.02 Bank supervision over the period 1977 - 86 averages more than one mission per year. The Bank's mission closely reviewed several problems occurred during the implementation of the project, and their comments overall helped ETRI's proper solution thereon. In addition, during the period of proceeding with the transfer of the Gumi facility to the private sector, and merger of two institutes (KIET and KETRI), the Bank assisted ETRI in leaping up the step of advanced research and development with a new semiconductor research facilities.

Working Relationship

8.03 The relationships between ETRI, the government of ROK and the Bank were overall reasonable. ETRI has always kept the Bank fully informed, as in the cases of proceeding with training and expert invitation programs as well as in the steps of the invitation to bid, bidding, the award of contracts for equipment procurement. Quarterly progress reports, yearly financial reports etc. have been also submitted to the Bank in accordance with the relavant provisions of the Project Agreement.

## IX. CONCLUSION

9.01 The project has made valuable contribution towards the technological development of the Korean electronics industry, especially with the emphasis on semiconductor and system areas, in order to achieve a high growth level. By virtue of development of ETRI's technological base, and the joint research program with and the services to the industry, ETRI has promoted and stimulated the industry's

technological development in the areas of the semiconductor and systems. Consequently, in 1986 ETRI and the industry began to carry out the higher level of research and development programs such as high density submicron VLSI technology, custom VLSI technology for telecommunication IC's, and super minicomputer technology with the creative conception and technology in 1986. Korea also began to enjoy import substitution and foreign export in the areas of semiconductor and computer related products and devices since 1985.

9.02 The institutional impact of the project has been significant. Based onthe former KIET's achievements of the technological development in the areas of semiconductor and systems, a future-oriented institution (ETRI) was established in 1985 in order to build the solid infrastructure for the information society in the 2000's. ETRI aims at carrying out the systematic research and development activities in the information engineering technology areas integrating telecommunications, computers, and sophisticated semiconductors. In this regard, the Gumi facility established under this project was transfered to the private sector in 1986, for the more economical utilization of the facility, and a new semiconductor research facility is under construction with the target of completion of its construction in September 1987.

9.03 The project seems unattractive in economic terms, due to the poor performance of the industrial services. This was caused by the late start-up operation of the semiconductor facility, and the industry's self-equipping of their semiconductor production facilities, which reduced the need for ETRI's provision of wafers. However, the supply of mask-sets ans testing to the industry were , in general, adequately performed to meet the demand for the industry. The RD&E program was not executed at all. This was caused by the industry's negative responses thereon at the early stage of the project, and by giving ETRI's major efforts to the national research program.

PROJECT COMPLETION REPORT

KOREA

ELECTRONICS TECHNOLOGY PROJECT
(Loan 1676-KO)

COMPLIANCE WITH COVENANTS

| Section | Covenant | Status |
|---|---|---|
| **Loan Agreement** | | |
| 3.02 | Government to provide ETRI with a US $500,000 advance to pay for Bank financed items in 1979 - 80. | Yes. |
| 4.02 (a) | Government to provide ETRI with such funds as operating costs, working capital requirements and capital expenditures in each year. | Yes. |
| 4.03 (a) | Periodical reviews by the Government of ETR staff compensation structure. | Yes. The Government has reviewed thestaff compensation structure at the annual Board Meeting. |
| **Project Agreement** | | |
| 2.02 | ETRI to enpoly experts to assist in carrying out the technology program. | Yes. |
| 2.03 | ETRI to enploy a semiconductor facility expert to assist in the supervision of construction of the semiconductor building. | Yes. |
| 2.06 (c) | ETRI to furnish the Bank with quarterly progress reports on the project implementation, procurement status of goods, technology and services. | Yes. |
| 2.08 (a) | ETRI to submit annually to the Bank a four-year RD&E progran and an annual technology acquisi- | Partial. Though poor progressed the RD&E |

| | | |
|---|---|---|
| | tion program. | program, the submission of these programs to the Bank had been made until 1984. |
| 2.09 (a) | ETRI to furnish the Bank with annual programs for training and experts invitation. | Yes. |
| 3.04 (b) | Except as the Bank agrees, ETRI shall not sell, lease, tranfer or dispose of its properties or assets. | Yes. |
| 3.05 | ETRI to establish and maintain a separate financial and accounting department to be headed by a qualified financial director. | Partial. A financial and accounting department was established in 1980 and abolished at the end of 1981. |
| 3.06 | ETRI to employ a technical advisor to assist in the discharge of its managerial functions. | Yes. |
| 3.07 | ETRI to adopt and implement a cost accounting system in consultation with the Bank. | No. Due to the poor progress of the services, the government's budget and accounting system has been continuously applied. |
| 3.08 | ETRI to adopt and implement a staff incentive system. | Partial. An incentive payment rule was adopted and implemented only in 1983. |
| 4.02 | ETRI to furnish the Bank the auditors with reports of acceptable scope and details within four months of the close of the fiscal year. | Yes. |
| 4.04 | Except as otherwise agreed with the Bank and until December 31, 1983, ETRI to make no capital expenditures exceeding $2,000,000 equivalent in any one year. | Yes. |

# ELECTRONICS TECHNOLOGY PROJECT
(Loan 1676-KO)

## BALANCE SHEETS

| | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 |
|---|---|---|---|---|---|---|---|---|
| **ASSETS** | | | | | | | | |
| Current Assets | | | | | | | | |
| . Cash | 38 | 184 | 291 | 3,585 | 2,136 | 6,356 | 19,002 | 33,303 |
| . Accounts Receivable | 744 | 286 | 233 | 167 | 445 | 255 | 3,134 | 2,719 |
| . Inventories | 60 | 38 | 144 | 98 | 640 | 488 | 1,438 | 1,812 |
| . Other Current Assets | 333 | 264 | 171 | 542 | 1,100 | 622 | 1,075 | 337 |
| Total Current Assets | 1,176 | 692 | 829 | 4,312 | 4,321 | 7,721 | 24,649 | 37,371 |
| Fixed Assets | | | | | | | | |
| . Gross Fixed Assets | 3,079 | 10,782 | 16,439 | 18,083 | 21,236 | 21,752 | 34,268 | 32,781 |
| . Less Depreciation | 36 | 136 | 730 | 2,179 | 3,910 | 5,803 | 1,922 | 4,569 |
| Net Fixed Assets | 3,043 | 10,646 | 15,709 | 15,904 | 17,326 | 15,949 | 32,346 | 28,212 |
| Other Assets | 414 | 325 | 111 | 125 | 106 | 190 | 6,050 | 21,248 |
| Total Assets | 4,633 | 11,663 | 16,649 | 20,341 | 21,753 | 23,860 | 63,045 | 86,831 |
| **LIABILITIES & CAPITAL** | | | | | | | | |
| Current Liabilities | - | 741 | 664 | 3,094 | 1,962 | 8,344 | 18,659 | 25,750 |
| Long-term Liabilities | 1,053 | 6,534 | 10,834 | 12,928 | 13,830 | 8,828 | 11,871 | 15,224 |
| (including Bank Loan) | (23) | (6,484) | (10,250) | (12,321) | (13,193) | (8,048) | (11,871) | (15,224) |
| Other Liabilities | - | - | - | - | - | 595 | 3,150 | 4,321 |
| Total Liabilities | 1,053 | 7,275 | 11,498 | 16,022 | 15,792 | 17,767 | 33,680 | 45,295 |
| Equity Fund | | | | | | | | |
| . Government Contribution | 3,021 | 4,452 | 5,652 | 6,380 | 6,737 | 7,819 | 7,964 | 24,041 |
| . Industry Contribution, etc. | 470 | 487 | 564 | 586 | 2,883 | 2,946 | 23,305 | 19,585 |
| . Earned Suplus/Deficit | 89 | -551 | -1,065 | -2,647 | -3,659 | -4,672 | -1,904 | -2,090 |
| Total Equity | 3,580 | 4,388 | 5,151 | 4,319 | 5,961 | 6,093 | 29,365 | 41,536 |
| Total Liabilities & Capital | 4,633 | 11,663 | 16,649 | 20,341 | 21,753 | 23,860 | 63,045 | 86,831 |

ANNEX 3

# ELECTRONICS TECHNOLOGY PROJECT
(Loan 1676-KO)

## INCOME STATEMENTS

| | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 |
|---|---|---|---|---|---|---|---|---|
| **REVENUES** | | | | | | | | |
| Project Revenues | 420 | 607 | 645 | 4,236 | 9,199 | 4,842 | 14,981 | 21,382 |
| Royalty Income | - | - | | 10 | 5 | 14 | - | 48 |
| Government Contrivution | 670 | 948 | 3,172 | 3,012 | 2,329 | 2,809 | - | 4,938 |
| Other Income | 185 | 409 | 293 | 142 | 1,215 | 669 | 1,568 | 9,833 |
| | 1,275 | 1,964 | 4,110 | 7,400 | 12,748 | 8,334 | 16,549 | 35,301 |
| **OPERATING EXPENSES** | | | | | | | | |
| Direct Cost | | | | | | | | |
| . Labor | 106 | 221 | 128 | 609 | 1,282 | 533 | 3,130 | 5,499 |
| . Materials | 229 | 280 | 222 | 759 | 723 | 558 | 2,425 | 4,625 |
| . Overheads | 3 | 157 | 208 | 2,127 | 6,026 | 2,796 | 4,829 | 11,388 |
| General and Administrative | 851 | 1,576 | 2,901 | 2,838 | 2,865 | 2,605 | 5,586 | 9,167 |
| Depreciation | 21 | 94 | 595 | 1,472 | 1,795 | 1,983 | 915 | 3,060 |
| | 1,210 | 2,248 | 4,054 | 7,805 | 12,691 | 8,475 | 16,885 | 33,651 |
| **OPERATING INCOME / LOSS** | 65 | -284 | 56 | 405 | 57 | -141 | -336 | 1,650 |
| LESS . Interest | - | 307 | 568 | 791 | 996 | 893 | 949 | 1,082 |
| . Other | 2 | 49 | 6 | 280 | 73 | 47 | 603 | 584 |
| . Income Tax | - | - | - | - | - | - | 16 | 126 |
| **NET INCOME / LOSS** | 63 | -640 | -518 | -1,476 | -1,012 | -1,081 | -1,904 | -142 |

# ELECTRONICS TECHNOLOGY PROJECT
(Loan 1676-KO)

## FUNDS FLOW STATEMENTS

| | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 |
|---|---|---|---|---|---|---|---|---|
| **SOURCES** | | | | | | | | |
| Internal cash Generation | | | | | | | | |
| . Net Income | 63 | -648 | -518 | -1,476 | -1,812 | -1,881 | -1,904 | -142 |
| . Depreciation, etc. | 70 | 387 | 827 | 2,761 | 4,490 | 2,532 | 7,131 | 26,808 |
| | 133 | -253 | 309 | 1,285 | 3,478 | 1,451 | 5,227 | 26,666 |
| Contributions | 1,376 | 1,449 | 1,277 | 750 | 2,654 | 1,146 | 13,238 | 12,248 |
| Long-term Borrowings | 22 | 6,381 | 4,743 | 1,475 | 1,808 | 89 | 199 | 2,645 |
| (Including Bank Loan) | | | (4,423) | (1,475) | (1,808) | (89) | | (2,645) |
| Prior Year Adjustment | - | - | 4 | 3 | 2 | 68 | - | - |
| | 1,531 | 7,577 | 6,333 | 3,453 | 7,942 | 2,754 | 18,664 | 41,559 |
| **APPLICATIONS** | | | | | | | | |
| Additions to Fixed Assets | 2,552 | 7,825 | 6,023 | 2,099 | 5,528 | 1,277 | 8,830 | 33,303 |
| Decrease in Long-term Debt | - | - | - | 120 | 1,193 | 4,319 | 3,787 | 2,027 |
| (Including Payment of IBRD Loan) | | | | - | (993) | (4,319) | (3,787) | (2,027) |
| Severance Payments to Employees | 10 | 12 | 68 | 72 | 79 | 140 | 57 | 159 |
| Prior Year Adjustment | - | - | - | 109 | 1 | - | - | 29 |
| | 2,562 | 7,837 | 6,091 | 2,400 | 6,801 | 5,736 | 12,674 | 35,518 |
| Change in Working Capital | -1,031 | -260 | 242 | 1,053 | 1,141 | -2,981 | 5,990 | 6,041 |
| **Total Applications** | 1,531 | 7,577 | 6,333 | 3,453 | 7,942 | 2,754 | 18,664 | 41,559 |